

200 years of Darwin wasp research (Hymenoptera, Ichneumonidae) in Southern Lower Saxony (Germany) with an annotated checklist

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<https://zoobank.org/5EF0E04B-8A6E-4288-AFF5-0E9ED4CC01AD>

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Academic editor: Stephan M. Blank | Received 6 September 2024 | Accepted 7 December 2024 | Published 13 January 2025

Abstract

A wide range of data was compiled from literature, insect collections and citizen science data with the aim to create an initial and preliminary regional checklist of Ichneumonid wasps for Southern Lower Saxony. In total, 1811 records of 876 Ichneumonid species were found, including 260 unpublished species records. The records originate from the last two centuries, two thirds being made in the last 90 years. The majority of data was collected by renowned Ichneumonid experts like Carl Gravenhorst, Erich Bauer and Rolf Hinz, but also by other scientists conducting surveys on ecological topics. Based on the compiled data, six Darwin wasp species could be added to the German Darwin wasp list, namely: *Camposcopus ruficoxis* (Schnee and Shaw, in prep.), *Coleocentrus soleatus* (Gravenhorst, 1829), *Netelia contiguator* Delrio, 1975, *Netelia silvaheercynia* Theunert, 2021, *Proclitus heterocerus* (Thomson, 1888) and *Tycherus acutus* (Gravenhorst, 1829). It can be assumed that the communities of Darwin wasps in the two main natural regions in Southern Lower Saxony, the Weser-Leine Uplands and Harz Mountains, differ in their composition, but this cannot be confirmed with certainty due to the low resolution and the different scope of the data. Apart from poorly studied locations, future surveys should focus on under-sampled habitats and include unrevised material to expand this regional checklist and give detailed information on habitat associations of Darwin wasp species.

Key Words

Harz, history, Ichneumonology, parasitoids, regional diversity, Weser-Leine-Bergland

Introduction

Parasitoids play a major role as biological control agents in forestry and agriculture (Kidd and Jervis 1997; Schmidt et al. 2003). As the use of chemical pesticides is becoming increasingly controversial nowadays (Chen et al. 2010; Leoci and Ruberti 2021), biological pest control is getting more attention. For some parasitoid groups, however, there is only limited knowledge on their biology. This also applies to Ichneumonid wasps, also known as Darwin wasps (Klopfstein et al. 2019b).

Their high diversity (Townes 1969; Yu et al. 2016) contrasts with a lack of entomologists interested in this group (Quicke 2015), which leads to missing information regarding their biology as well as on their distribution.

In 1829, Gravenhorst published a three-volume monograph on the Darwin wasps of Europe. Since then, species numbers have increased, the knowledge of their taxonomy has improved, and efforts are now being made to compile national inventories (Broad 2016; Klopfstein et al. 2019a; Verheyde et al. 2021; Varga 2024). With their help, the large-scale distribution of species in Europe can be depicted in more detail than Gravenhorst was able to do.

The newest checklist for German Ichneumonids by Riedel et al. (2021) includes a number of 3644 species, which is still growing (pers. comm. Riedel). This number represents about one third of all Hymenopteran species (Dathe and Blank 2004) and around 10% of all insect species known for Germany (Klausnitzer 2005). However, although it is the most extensive taxonomic list, it does

not provide information on the regional occurrence of species in Germany.

While high resolution distribution maps for Ichneumonids seem a long way off due to limited data availability, regional surveys can provide information about their phenology. Accordingly, Klaus Horstmann, one of the most renowned Darwin wasp specialists of the past decades, pointed out: [...] *It is very desirable to analyse the regional distribution of individual species in detail, as this provides information on their way of life* (Horstmann 2002a). However, rearing studies are needed to identify the hosts, as these are still unknown for many Darwin wasp species.

As Quicke (2015) has shown, publications dealing with Ichneumonid wasps have been published infrequently compared to studies involving other parasitoids, like Braconid wasps. However, since the turn of the 21st century, Ichneumonid wasps have increasingly appeared in publications, which can be attributed to the work of Klaus Horstmann. These publications were primarily dealing with taxonomic revisions (which are indeed of great importance for this group), rather than with regional occurrence of species.

There are several species lists of the regional Darwin wasp fauna in Germany, e.g. for Franconia (Bauer 1958), Northwest Germany (Kettner and Wagner 1954; Kettner 1968, 1971), the East Frisian Islands (Horstmann 2008a), Thuringia (Müller 2020, 2021) and others. However, some regions such as East Germany are not yet very well surveyed, which is also true for the southern part of Lower Saxony. Although Lower Saxony is situated in Northwest Germany, the southern part was less considered in the lists of Kettner (1968, 1971). Southern Lower Saxony differs from the rest of the federal state, as it belongs to the low mountain range, and in contrast to the northern lowlands of Lower Saxony, is considered a Continental instead of an Atlantic biogeographical region (BfN 2011). It is dominated by the Weser-Leine Uplands and the Harz Mountains. The list of Ichneumonid wasps from Southern Lower Saxony compiled by Kettner (1968, 1971) could be extended by taking previously unconsidered data into account. Such data could be found in entomological collections, taxonomic reviews and ecological surveys.

Thus, the aim of this work, is to improve the limited knowledge of the regional Darwin wasp diversity in Southern Lower Saxony by compiling data from insect collections, citizen science data, ecological and taxonomic publications with Ichneumonid specimens from this region, and also to provide an overview of the local history of ichneumonology.

Material and methods

Region

Southern Lower Saxony includes the districts Göttingen (GÖ), Goslar (GS), Northeim (NOM), Holzminden (HOL) and the municipalities Alfeld (Leine), Freden and Lamspringe in Southern Hildesheim (HI). As wildlife is attached to habitats rather than administrative borders, a buffer zone of 5 km around this area was also taken

into account, which extends to Hesse, Thuringia, North Rhine-Westphalia and Saxony-Anhalt. Beside the districts and municipalities, the natural regions according to BfN (2011) were used to describe the habitat characteristics.

The following natural regions, including their ID, as defined by the BfN (2011), were considered in the selected area (see Fig. 1):

- D18 Thüringer Becken und Randplatten (Thuringian Basin and peripheral Uplands)
- D33 Nördliches Harzvorland (Northern Harz Foreland)
- D36 Weser-Leinebergland (Weser-Leine Uplands)
- D37 Harz (Harz Mountains)
- D46 Westhessisches Bergland (Western Hessian Highlands)
- D47 Osthessischen Bergland (Eastern Hessian Highlands)

The greatest part of the area is characterized as Weser-Leine Uplands, which is a very heterogeneously structured landscape with agricultural areas and deciduous or mixed forests. Above an altitude of 400 meters, coniferous forests dominate, as in the Solling region. The Harz Mountains is the natural region with the second largest area. Its altitudes range from 400 to 1141 meters and are dominated by coniferous forests, moors and heathland. Deciduous forests can only be found at lower altitudes in the peripheral areas. The other natural regions, which only have low area coverage, are more similar to the Weser-Leine Uplands (von Drachenfels 2010; Bundesamt für Kartographie und Geodäsie 2018).

Literature research

For literature research, the databases “Web of Science” (<https://www.webofscience.com>), “Zoologisch-Botanische Datenbank” (<https://www.zobodat.at>) and “Google Scholar” (<https://scholar.google.de>) as well as the reference search in the database “Taxapad” (Yu et al. 2016) were used with the following keywords: “ichneumonidae” or “parasitoids” in pairwise combination with “Germany”, “Lower Saxony”, “Göttingen”, “Harz” or “Solling” as well as their German counterparts. Following this, the reference lists of relevant publications were checked to find further literature that was not found during the previous literature research. In order to find reports outside of scientific journals, the internet search engine Google (<https://www.google.com>) was used with the same keywords. From all results, only those with a regional relevance were taken into account. In total, 73 articles were identified, including 845 individual observations.

Citizen science data

The Global Biodiversity Information Facility “GBIF” (<http://gbif.org>) provides biodiversity data from various citizen science platforms, institutes or peer-reviewed

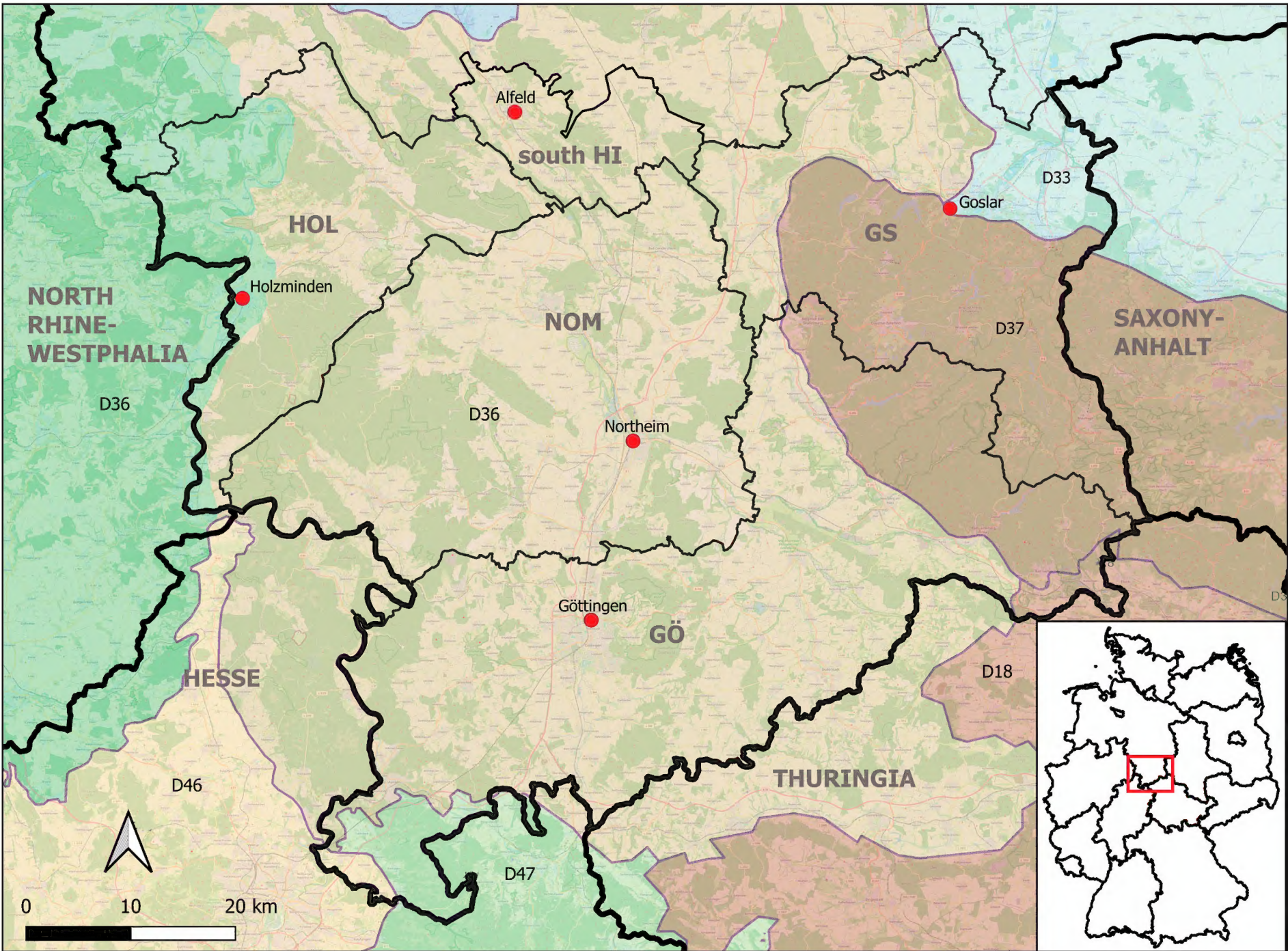


Figure 1. Map of Southern Lower Saxony. Bold black line = Borders of the federal states, fine black lines = districts (including their abbreviations), purple line = borders of the natural regions. The different natural regions are color-coded and marked with their ID after BfN. (source: <https://www.openstreetmap.org>, <https://www.lgln.niedersachsen.de>, and <https://geodienste.bfn.de>).

works. Here, it was searched for records of Ichneumonids until the 31st of December 2023. Using the geographical selection tool, the data set was filtered for entries from the considered area and downloaded at the 12th of January 2024 (<https://doi.org/10.15468/dl.b5bjky>). Not reviewed or doubtful records (e. g. with pictures of low-quality / uninformative pictures or without any pictures or link) were excluded from the data set. This means that records from the platform naturgucker.de were not taken into account, as the observations are not validated and no links to the respective observations are provided. Reports of extinct species were excluded as well. The reduced data set consisted of 112 records from six sources.

Insect collections

The following collections were considered:

AECG	Agrarökologie	Georg-August-Universität, Göttingen
AENG	Agrarentomologie	Georg-August-Universität, Göttingen
IFUG	Forstzoologie und Waldschutz	Georg-August-Universität, Göttingen

SDEI	Senckenberg Deutsche Entomologische Institut, Müncheberg
SFNF	Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt/M.
LIB	Leibnitz-Institut zur Analyse des Biodiversitätswandels, Hamburg

Further, private collections were taken into account:

Matthias Riedel – Bad Fallingbostel
Heinz Schnee – Markkleeberg
Mike Kuschereitz – Göttingen

Due to construction work, the Darwin wasp collection of the Zoologische Staatssammlung München (ZSM) was not accessible during this work. Data from ZSM and other collections or institutes were included as far as they were accessible through the Global Biodiversity Information Facility “GBIF” (<http://gbif.org>).

Data assessment

For every record, all available details were noted, but at least species name, date of record, location and source. The name

of the collector/observer was used to narrow down the collection date to a certain period, if it is not explicitly noted on the specimen label. Only the presence of a species per year and location was taken into account, not the number of specimens. For the complete database, see Suppl. material 2.

In the case of some records, especially as regards unrevised historical specimens, it is assumed that the determination cannot always be considered reliable. Nevertheless, these records were taken into account as it is not possible to distinguish between reliable and unreliable determinations. Clearly questionable records, like those species without taxonomic revision, were excluded.

Due to this uncertainty in historical records, a separation was made between data before (1809–1933) and from 1934 (1934–2023).

The purpose was to localize the site of each species record with as much accuracy as possible. Location details include a specific city, area or notable geographical points such as mountains or hills. Due to this information, records could be assigned to a certain natural region.

In some cases, records from the Harz Mountains were found without exact location details. Although the Harz is not only located in Lower Saxony, but also in Thuringia and Saxony-Anhalt, it is regarded as one and the same natural region. Records that could not clearly be assigned to one of these federal states were also taken into account, as these specimens could also originate from the Lower Saxony part of the Harz Mountains.

From all records, the temporal and spatial coverage of each Ichneumonid wasp survey was evaluated to show from which period most records originate and which areas were less or better investigated.

Checklist

Based on the data collected, a species list was compiled containing both temporal and spatial information. Additionally, it was noted whether species records were only based on unrevised historical specimen or citizen science data.

For this checklist, the same criteria were applied that were used by Horstmann (2002a) and later on by Riedel et al. (2021): No taxa were included, that were described before 1945 and have not been recovered or revised since then. Phylogeny is based on Bennett et al. (2019) and the same nomenclature is used as listed in Riedel et al. (2021) with the exception of the genera *Camposcopus* Förster, 1869 which previously was claimed to be a subgenera of the genera *Habronyx* Förster, 1869 but here treated as own genera following the opinions of Schnee (2018).

Results

Records

In total, 1811 records of Darwin wasps from 82 sources have been found. 855 records came from the nine considered

insect collections. 844 records originate from literature and the remaining 112 records came from the data bases GBIF.org. 600 records were taken from 1809 to 1933 and 1194 have been taken since 1934. 17 records were reported without a date. Most of the historical records are based on Gravenhorst and the collection of Otto Ludwig Wissmann (IFUG; see Table 1). Records from the period after 1934, mostly come from the AENG, followed by SDEI and GBIF.org (which also includes data of other collections like ZSM).

Table 1. The sources with more than 50 records, representing about 80% of all records.

Source	Number of records
Gravenhorst (1829)	332
AENG (coll. Prilop)	310
IFUG (coll. Wissmann)	223
SDEI	121
GBIF.org	111
LIB	92
Ulrich (2001)	80
Kettner (1968)	53
Hinz (1961)	52
SFNF	52
Riedel (private coll.)	51

The first record from Southern Lower Saxony with a precise date is *Diphyus monitorius* (Panzer, 1801) from 07.07.1809 reported by Gravenhorst (1829). While the historical records before 1934 are mainly based on two entomologists (see Fig. 2), the number of Darwin wasp collectors increased after World War II. In addition to Rolf Hinz, whose data were mainly collected from the 1940s to 1960s, a few other scientists considered Darwin wasps in their studies with various scientific aims. It was found that specimens in the SDEI originate from the Northwest German Forest Research Institute (NW-FVA). In the 1980s, Werner Ulrich studied the Hymenopteran fauna of forests and meadows around Göttingen. After 1987, no more surveys were conducted in Southern Lower Saxony that included detailed assessment of Ichneumonidae. The only data set from the last thirty years, apart from citizen science data, comes from Matthias Riedel from 2008, who collected Darwin wasps while on vacation (Riedel pers. comm.).

With regard to the distribution and frequency of records (Fig. 3), the data show that the city of Göttingen and its surroundings as well as the Harz Mountains are the dominant collecting areas. In the district of Northeim (NOM), the location with the most records is Einbeck, where Rolf Hinz lived and collected Ichneumonid wasps. Data from Holzminden (HOL) is quite limited. A total of 110 locations were identified where Darwin wasps were collected.

Species richness

In total, 876 species from 28 subfamilies were recorded in the Southern part of Lower Saxony (Table 2). 410 species were found in the period before 1934, including 225 species

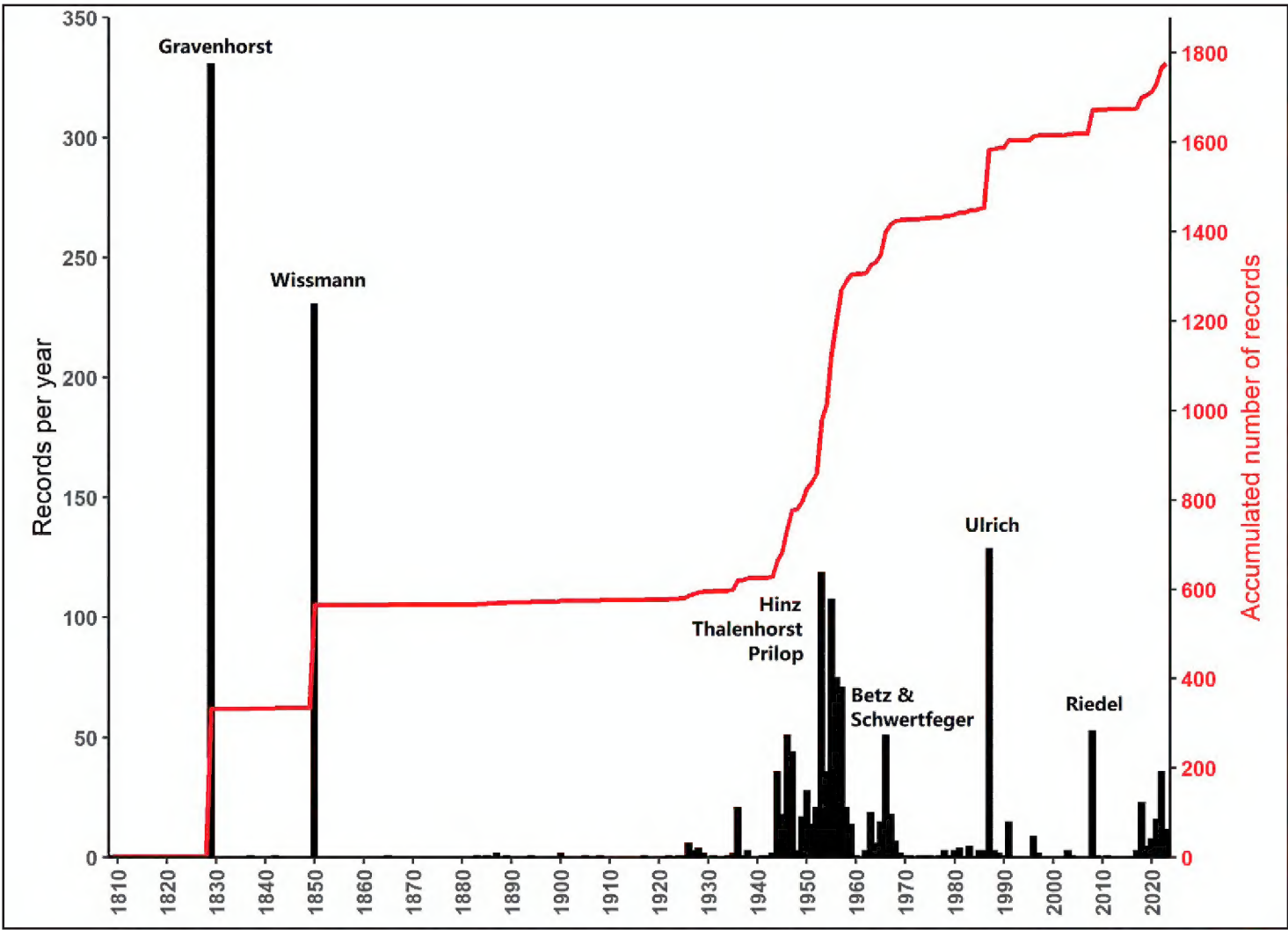


Figure 2. Number of records per year (black bars, primary axis on the left) and cumulative number of records (red line, secondary axis on the right) from 1809 to 2023. The collectors of the largest data sets are named. Records without specific date are not considered.

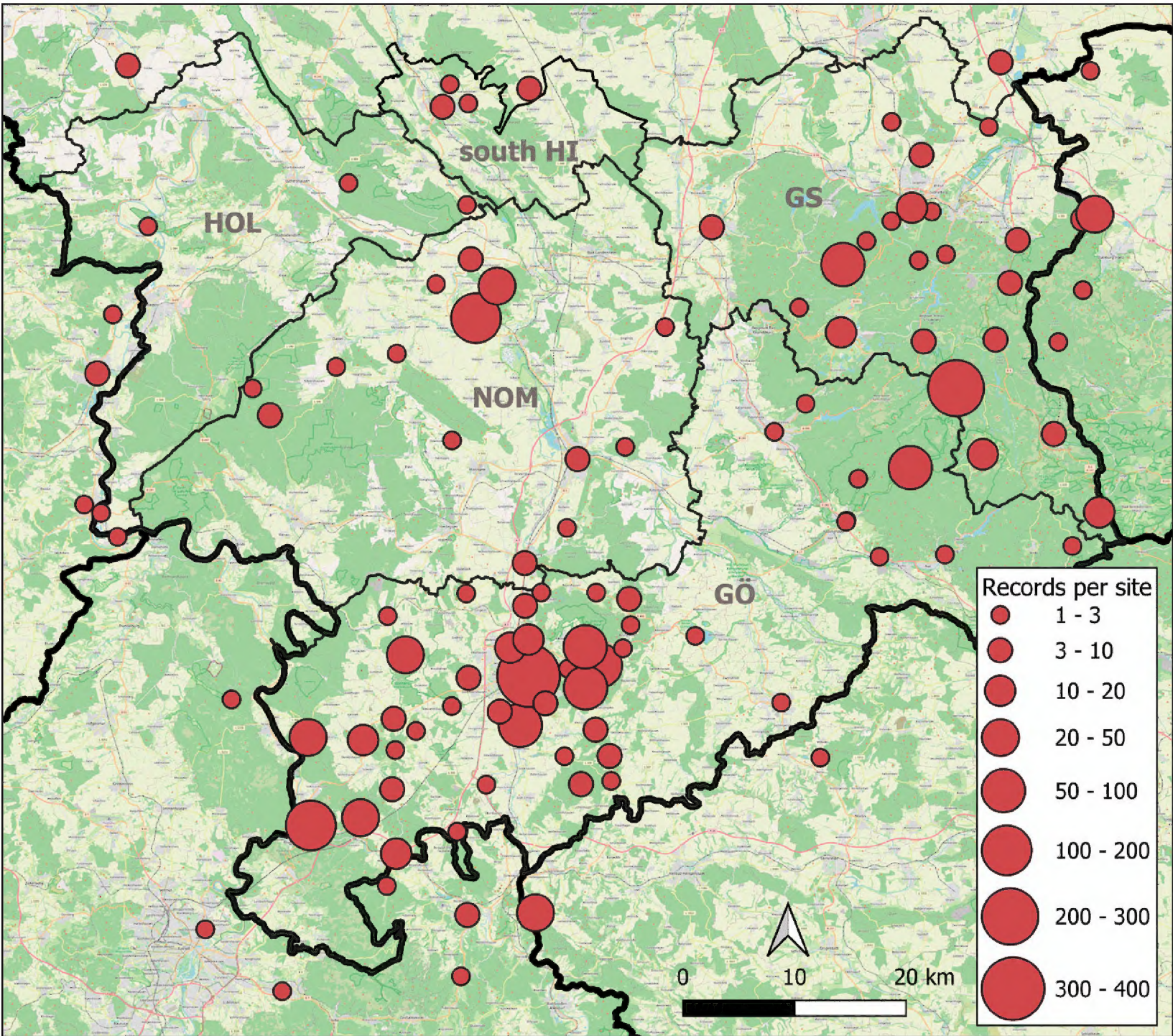


Figure 3. Frequency and distribution of Darwin wasp records of Southern Lower Saxony and its surroundings (source: <https://www.openstreetmap.org>, <https://www.lgln.niedersachsen.de>).

that were not recorded again afterwards. Here, 55 species records are only based on specimens from the IFUG.

Within the last 90 years, 645 species were reported. In comparison to the period before 1934, 459 species were reported for the first time. Eight species have only been reported by Citizen Science platforms. Only 185 species were collected in both periods and 7 species could not be assigned to any period due to missing data.

Table 2. Number of Ichneumonidae species per subfamily recorded in Southern Lower Saxony. A comparison to the current checklist by Riedel et al. (2021) is given.

Subfamily	Species found in Southern Lower Saxony	Species known for Germany (Riedel et al. 2021)
Acaenitinae	4	14
Adelognathinae	1	23
Agriotypinae	0	1
Anomaloninae	16	62
Ateleutinae	1	1
Banchinae	51	184
Brachycyrtinae	0	1
Campopleginae	93	498
Collyriinae	2	2
Cremastinae	5	26
Cryptinae	62	230
Ctenopelmatinae	101	420
Cylloceriinae	3	7
Diacritinae	0	1
Diplazontinae	25	68
Eucerotinae	2	4
Hybrizontinae	0	5
Ichneumoninae	172	638
Lycorininae	0	1
Mesochorinae	19	175
Metopiinae	11	93
Microleptinae	1	3
Neorhacodinae	0	1
Ophioninae	15	41
Orthocentrinae	36	151
Orthopelmatinae	1	2
Oxytorinae	0	2
Phygadeuontinae	107	468
Pimplinae	39	146
Poemeniinae	7	11
Rhyssinae	3	9
Stilbopinae	2	6
Tersilochinae	29	113
Tryphoninae	58	208
Xoridinae	10	29
Number of species	876	3644

While most of the species recorded for Southern Lower Saxony belong to the more diverse Ichneumonidae subfamilies, the less diverse subfamilies in particular have not yet been recorded in Southern Lower Saxony. These includes Agriotypinae, Brachycyrtinae, Diacritinae, Hybrizontinae, Lycorininae, Neorhacodinae and Oxytorinae.

The species list (Suppl. material 1) is sorted by subfamilies. The records are divided into those dating from

before (1809–1933) and from (1934–2023) 1934 onwards. A question mark (?) is used for records without any date indication. The following codes are used in the notes to indicate whether species were recorded in a single natural region (according to BfN):

- A: Species records only from Weser-Leine Uplands (D36)
- B: Species records only from Harz Mountains (D37)
- C: Species records only from other natural regions

A number coding is used to indicate that the species records are based only on unrevised historical material or citizen science data. Species not included in the current checklist for Germany (Riedel et al. 2021) are marked as well.

- 1: Species records before 1934 are only based on not revised specimens (IFUG)
- 2: Species records from 1934 onwards are only based on citizen science data
- 3: Species not included in the current checklist for Germany (Riedel et al. 2021)

Habitat associations

Of all the records, only 418 contained detailed information about the habitat in which they were found. This concerned 387 records from the Weser-Leine Uplands, 30 records from the Harz Mountains and one record from the eastern Hessian Highlands. However, as records can be assigned to a natural region at least, the narrowed down rough environment characteristics can be derived and used for information on habitat requirements.

The majority of records originate from the Weser-Leine Uplands, where 681 species were found. 449 species only occur in this natural region. The 518 records from the Harz Mountains contain 372 species, of which 163 species were not reported in any of the other natural regions.

The remaining 90 records contain 87 species, and come from the other natural regions. Here, 25 species were recorded that do not occur in either the Weser-Leine Uplands or the Harz Mountains (Table 3).

Table 3. Number of records and number of species per natural region.

Natural region (after BfN)	Number of records	Number of species	Number of species found only in this natural region (% of all species)
D36 Weser-Leine Uplands	1204	681	449 (51%)
D37 Harz Mountains	518	372	163 (19%)
D47 Eastern Hessian Highlands	51	49	18 (2%)
D33 Northern Harz Foreland	38	37	6 (0.7%)
D46 Western Hessian Highlands	1	1	1 (0.1%)

Discussion

Data resources

The data on which this work is based is of varying origin and quality. It was unexpected that the number of unpublished data in entomological collections was so high. Overall, 1811 records of 876 species were found. The nine considered insect collections provided 855 records of 533 species compared to 605 species within 956 records from published literature and citizen science data. This means that around 260 species had not yet been published for this region. However, this number is based on the assumption that unpublished species were correctly determined. As in some cases it is not noted who did the determination, and it is not possible to prove the validity without redetermining these specimens. In the case of 55 species from unrevised specimens, this determination should be verified, as this species records are based on these specimens only. Even in cases where the person who did the determination is known, misidentification can be assumed. After Horstmann (2008a), determinations before 1950 should be taken carefully due to a lack of taxonomical revisions. Even determinations of renowned entomologists like Schwenke, Aerts, Pfankuch or Kettner are known to be partly incorrect (Horstmann 2008a; Klopstein et al. 2019; Matthias Riedel pers. comm.). However, records identified by those experts were taken into account, as it is not possible to review all these specimens if they are preserved. Data generated by citizen science platforms should also be treated with caution. This data is based on images only and as determination can be difficult even for specialists, records from lay persons should be questioned even more. For this work, citizen science data were only included if records were revised and authorized by validators. There is still a risk of misidentifications, but as most of the validated records from citizen science are common or easily recognisable species, the rate is likely to be minimal. In the case of eight species, which have been found by citizen science platforms only, a verification should be conducted by caught specimens.

Another issue about the data is that most records do not provide any information about the habitats where the specimens were found. Thus, it is difficult to give reliable indication on habitat requirements based on this work. Such information can help in further investigation on species with unknown biology.

The data included in this work cannot be assumed to be a complete inventory, as some collections like the ZSM could not be reviewed. It is expected that there are many specimens and rearing results stored from the collections of Hinz and E. Bauer, not mentioned in publications. Additional, unidentified or unreviewed specimens are also preserved in the collections in Göttingen, including collected samples from recent surveys.

History of regional Ichneumonology

In total, we can look back on about 200 years of Darwin wasp research in Southern Lower Saxony. First records of Ichneumonid species from this region are mentioned in Gravenhorst's monographies "Vergleichende Übersicht des Linneischen und einiger neuern zoologischen Systeme" and "Ichneumonologica europaea" and date back to the beginning of the 19th century (Gravenhorst 1807, 1829). The name Gravenhorst inevitably comes to mind when dealing with Ichneumonid wasps in Europe, as his work and collection are of fundamental importance for the systematics of European Darwin wasps (Horstmann 1992). Specimens of Gravenhorst's collection are still conserved in Wrocław and even revised, but as most of them have no labels anymore, it is hard to confirm their origin (e.g. Townes 1965; Horstmann 1992). However, the work of Gravenhorst still serves as an initial data base for this compilation. Such extensive historical data are rare and only came from a few entomologists like Arnold Förster, who collected Darwin wasps from the Rhineland as early as the middle of the 19th century (Aerts 1956).

Further, the hymenopteran collection of Otto Ludwig Wissmann (IFUG) includes Ichneumonidae from the 19th century. This collection is in general in good condition and the labelling is still available. The labels at least indicate the places where the specimens were collected, and on this basis, it is possible to make rough estimates of their collection date: Wissmann was a teacher in the Berg- und Forstschule in Clausthal in the Harz Mountains from 1842 to 1844. After that, he moved to Hann. Münden for teaching in the Forstschule until its closure in 1849 (Lier 1898). It is therefore very likely that specimens from his collection, where these places are indicated on the labels, originate from these periods. As a few specimens from Wissmann's collection got extra labels with "Hartig" or "Ratzeb." it was already assumed by Horstmann (1985) that Wissmann got specimens from both Hartig and Ratzeburg in exchange, including specimens from Southern Lower Saxony. What exactly happened with his collection after 1849 is not known. However, according to Horn and Kahle (1937) it was stored in the 1922 founded Forestry University in Hann. Münden, before it moved to Göttingen (Weißbecker et al. 2018).

As many species descriptions from this period contain little information, they were not very useful for the comparative identification of species. Therefore, revisions and identification keys were necessary, which were carried out by different authors like Holmgren (1860), Förster (1876), Schmiedeknecht (1902) and Pfankuch (1906).

Such work was important for the following developments in Darwin wasp research, especially for systematics, but it took about 70 years (1849–1914) until Erich Bauer in Goslar revived interest in Ichneumonidae in Southern Lower Saxony. From the 1920s, Bauer collected a lot in the Harz Mountains, but published little about it (Bauer 1928). He handed his collection to the ZSM in Munich in 1967 (Horstmann 1983).

After World War II, Rolf Hinz from Einbeck continued the research of the Darwin wasp fauna in Southern Lower Saxony. He investigated host associations and reared many Ichneumonids with the aim to extend the knowledge on their biology and host preferences, but also to identify and assign the males in various species (Hinz and Horstmann 1998, 2007).

In this way, Hinz collected a lot of wasps from the 1940s to the 1960s, but also carried out determination for regional scientists. This includes specimens from arthropod studies in sugar beet, run by Prilop in 1953, as well as parasitoids from surveys on phyllophagous pest insects of deciduous and coniferous forests run by the forestry research centre (Thalenhorst 1960; Betz and Schwertfeger 1970).

Besides that, Darwin wasps were rarely included in surveys within this region, as identification is considered to be difficult and can only be done by a limited number of experts. The latest scientific study was therefore carried out in 1987 by Ulrich, who investigated the hymenopteran diversity in beech forests and calcareous grassland around Göttingen (Ulrich 2001, 2005). In the scientific publications of the last 40 years from this region, Ichneumonid wasps have hardly been mentioned, with the exception of some parasitoids of certain groups such as solitary bees (Gathmann 1999).

For some years now, there have been several citizen science platforms that also report arthropod observations. Such data can hardly compensate for the lack of scientific surveys, as validation of these observations is necessary and can only be performed for common and easily recognisable species. Nevertheless, this data can help to gain more precise knowledge on their occurrence (Chandler et al. 2017).

Species richness & distribution

With 876 species, around a quarter of Darwin wasps known for Germany have been reported for Southern Lower Saxony and its surroundings. This number seems relatively low compared to other regional checklists e.g. 1400 species from Franconia (Bauer 1961) or 1800 species from the Rhineland (Aerts 1956). However, these regions are larger and also have a more extensive database.

Thus, the actual number of Ichneumonid species in Southern Lower Saxony can be assumed to be much higher than 876, as the data from the ZSM/Munich could not be included. Additionally, there are still some knowledge gaps in terms of under-sampled areas, but also in terms of specific habitats. For instance, there are no records of seven subfamilies, some of which require specific structures, such as ant colonies in the case of the Hybrizontinae (Broad et al. 2018).

Despite the incompleteness of this regional checklist, the following six species could be added to the Darwin wasp fauna of Germany, which were only recently reported or whose revisions were overlooked by Riedel et al. (2021):

Camposcopus ruficoxis (Schnee and Shaw, in prep) (Anomaloninae): ♀ 2.6.1946 Göttingen; ♂ 17.6.1964 Harz Mountains; ♂ 20.6.1954 Hils, all leg. R. Hinz

(coll. Schnee). This species is currently under revision by Schnee and Shaw (Schnee pers. comm.).

Coleocentrus soleatus (Gravenhorst, 1829) (Acaentinae): Reported by Gravenhorst (1829) from the Harz Mountains. This species was revised by Kasparyan and Khalaim (2007).

Netelia contiguator Delrio, 1975 (Tryphoninae): A record from 2021 found in the Harz Nationalpark by light trapping, leg. M. Jung, det. R. Theunert (Jung 2022).

Netelia silvahercynia Theunert, 2021 (Tryphoninae): New species, 1 ♂ 15.7.2021 Harz Nationalpark by light trapping, 820 m, leg., det. & coll. R. Theunert (Theunert 2021).

Proclitus heterocerus (Thomson, 1888) (Orthocentrinae): leg. Prilop 1956, Göttingen, det. Aerts (AENG). This species was synonymized with *P. fulvicornis* Förster, 1871 by van Rossem (1983) but its status was resurrected by Humala (2007).

Tycherus acutus (Gravenhorst, 1829) (Ichneumoninae): Reported by Gravenhorst (1829) from the Harz Mountains. This species was revised by Sebald et al. (2000).

The number of records, as well as the species richness differs in the two main natural regions with higher numbers in the Weser-Leine Upland. The differences in species numbers between the Harz and the Weser-Leine Uplands correlate with the number of records per natural region. Even if the data suggests that there are different Darwin wasp communities in these two natural regions, the database is too small to clearly support this assumption, as there are only single records for many species and the number of records differ from each other.

Nevertheless, this offers further aspects for research, especially in view of the ongoing fundamental environmental changes, particularly in the Harz Mountains, where calamities have led to a loss of more than 42% of the tree cover since 2000 (Global Forest Watch 2024). Habitat changes due to this forest loss, but possibly also due to the ongoing reforestation measures, may affect this biocenosis and change the diversity of Darwin wasps, for example by influencing the population dynamics of their hosts.

Regional checklists are important contributions to the knowledge of species distribution, but also of their habitat preference, as far as this information is available. They also form the basis for national checklists and can help to extend them, as shown here and in various recent publications (Bendixen 2022; Müller 2022, 2023).

Conclusion

This work represents a preliminary species list. Further work is required with the aim of expanding it. This could be done by adding recent observations or records including habitat information. In particular, regions with few published records of Ichneumonid wasps, such as Solling, should be considered. Such data may already exist due to research projects of any kind, but may not yet have been

analysed. Once it is accessible again, the Zoologische Staatssammlung München (SNSB) could also contribute to the expansion of this list, as further specimens collected by Rolf Hinz and E. Bauer from Southern Lower Saxony will be found here. Finally, a revision of the Wissmann collection (IFUG) could help to confirm historical records as it allows us to look back and possibly help to show changes in the regional diversity of Darwin wasps over time.

Acknowledgements

Special thanks goes to Matthias Riedel (Bad Fallingb.-tel) - for the exchange on the taxonomic status of species and recommendations on literature as well as for reviewing this manuscript.

Further thanks to: Heinz Schnee – for information on species names in the Anomaloninae.

Felix Kirsch – for his help in searching several insect boxes and checking this manuscript.

Nicole Beyer & Jamie – for the nice weekends at the institute, with constructive discussions in connection with the present work and for checking it.

Brendon Boudinot and Patricia Peters (SFNF), Andrew Liston (SDEI), Sara Nicke-Mühlfeit (IFUG), Catrin Westphal and Susanne Jahn (AECG), Michael Rostas, Jonas Wattenrott and Bernd Ulber (AENG), Eileen Nguyen (LIB) for access to the respective collections and other support.

Gerrit Holighaus (NW-FVA – Nordwestdeutsche forstliche Versuchsanstalt, Göttingen) - for arranging contacts and for tips on the manuscript.

Peter Mansfeld (NMOK – Naturkunde Museum Ottoneum, Kassel) – for finding the ichneumonids, even if there were unfortunately no determined specimen from the area we worked on.

And finally thanks to Martin Schwarz for reviewing this manuscript.

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Supplementary material 1

Annotated Checklist of the Darwin wasps of Southern Lower Saxony

Authors: Mike Kuschereitz

Data type: xlsx

Explanation note: Species list.

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Link: <https://doi.org/10.3897/contrib.entomol.75.e136366.suppl1>

Supplementary material 2

List of gathered data from all found records

Authors: Mike Kuschereitz

Data type: xlsx

Explanation note: Raw data set.

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